REMARKS

In reply to the Office Action of January 27, 2009, Applicant submits the following remarks. Claims 1, 3 and 5 has been amended. Support for the amendment to claim 1 can be found at least in the specification as filed at page 3, lines 12-14. Claim 1 was also amended to change "a substrate" to "the substrate". Claims 3 and 5 were amended to change "techniques" to "technique", i.e., correct a typographical error. Applicant respectfully requests reconsideration in view of the foregoing amendments and these remarks.

Section 102 Rejections

Claim 1 was rejected under 35 U.S.C. § 102(e) as being anticipated by U.S. Publication No. 2003/0194859 ("Huang"). Applicant respectfully disagrees in light of the amendment to claim 1.

Amended claim 1 is directed to a method for forming an arrangement of two barrier layers on a substrate. The method includes modifying at least a portion of a second surface of a first ceramic barrier layer to introduce first nucleation sites on the second surface. A second ceramic barrier layer is formed directly on the second surface of the first ceramic barrier layer without continuing all defects of the first ceramic barrier layer, wherein the second ceramic barrier layer is initiated at the first nucleation sites. The first ceramic barrier layer and the second ceramic barrier layer together have enhanced barrier capabilities against gas and liquid as compared to two similar adjacent ceramic barrier layers formed without the modifying step to introduce nucleation sites.

Huang describes a problem that can occur with contact plugs of aluminum or tungsten ions from the contact migrating into the silicon substrate through a doped region (paragraph 6). This can cause shorting to the substrate. Barrier layers, such as TiN, are used to mitigate shorting. However, one problem with the barrier layers is that they need to be thick enough to effectively function as a barrier layer. As integrated circuits are formed with finer and finer features, the diameter of the contact shrinks and thick barrier layers are no longer feasible or desirablé. An additional problem with the barrier layers for contacts is that during a thermal

process, oxygen from the ambient air reacts with barrier metal to form an oxide film on the surface of the barrier metal (paragraph 9). The oxide film causes the layer to have a similar zeta potential value as a subsequently applied tungsten film, which can lead to voids in the tungsten layer and can prevent the tungsten layer from adhering onto the surface of the barrier metal layer (paragraph 10). The poor adhesion due to the similar zeta potential in combination with the different thermal coefficient of expansion between the tungsten and the dielectric material leads to thermal stress and cracking. In turn, the cracking allows for migration of tungsten into the silicon substrate.

Huang proposes methods that improve the adhesion ability between a dielectric layer and a conductive layer so that cracking or fracturing of the barrier metal layer can be prevented (paragraph 14). This eliminates defects due to electromigration (paragraph 16).

A dielectric layer 104 on a silicon substrate 100 is etched to form a contact opening 108, exposing a conductive region within the contact opening (paragraphs 25-27). The contact opening is coated with a first refractory metal layer 110. Next, a first refractory metal nitride layer 112 is formed over the first refractory metal layer 110. A first plasma treatment 125 is carried out to removes impurities, such as carbon and oxides from the metal nitride layer 112 (paragraph 28). The plasma process also reduces the thickness of the layer 112 from about 120-160 angstroms to about 40-60 angstroms to form a thinner metal nitride barrier layer 114. A thermal-process 126, such as rapid-thermal-process (RTP), is carried out in order to effect a reaction between the silicon atoms of the conductive region and the first refractory metal layer to form a metal-silicide (paragraph 29). The RTP is carried out at 550-700° C.

A second refractory metal nitride layer 118 is formed on the first metal nitride barrier layer 114 (paragraph 30). A second plasma treatment 127 is carried out to remove impurities and to transform the second refractory metal nitride layer 118 into a thinner second metal nitride barrier layer 120 (paragraph 31).

Although Huang describes plasma treating a refractory metal nitride layer, Huang fails to suggest or disclose forming a second ceramic barrier layer directly on the second surface of the first ceramic barrier layer without continuing all defects of the first ceramic barrier layer, wherein the second ceramic barrier layer is initiated at the first nucleation sites. Moreover, Huang's barrier layers do not have enhanced barrier capabilities against gas and liquid.

Huang does not teach that the plasma treatment step forms nucleation sites on the surface of the plasma treated barrier layer. A person of skill in the art would not determine from Huang that the plasma treatment is used to form nucleation sites. Huang's plasma treatment reduces the thickness of the metal nitride barrier layer and removes impurities. The removal of impurities leads to increased adhesion. Improving the adhesion between the dielectric layer and conductive layer prevents cracking and fracturing of the barrier metal layer caused by voids in a tungsten layer, poor adhesion due to zeta potential and a different in thermal coefficient of expansion between the conductive layer and the dielectric layer. Preventing cracking prevents metal migration through the layer. Huang is not concerned with forming a barrier layer with enhanced barrier capabilities against gas and liquid. Rather, Huang is concerned with metal migration through cracks or fractures of the barrier layer and prevent the cracks by improving adhesion between layers, not by forming a second barrier layer without continuing all defects of the first ceramic barrier layer. Further, assuming *arguendo* that nucleation sites are formed by Huang when plasma treatment is performed, Huang also performs a rapid thermal treatment. The heating process would cause any nucleation sites to disappear.

For at least theses reasons, applicant submits that Huang's process of applying and treating barrier layers does not anticipate claim 1 as amended.

<u>Section 103 Rejections</u>

Claims 1-3, 6, 7, 10-15 and 17-26

Claims 1-3, 6, 7, 10-15 and 17-26 were rejected under 35 U.S.C. § 102(a) as being unpatentable over U.S. Publication No. 2003/0203210 ("Graff '210") in view of Huang. Applicant respectfully disagrees in light of the amendment to claim 1.

Amended claim 1 is the only pending independent claim.

Graff describes plasma treating a surface of a foundation barrier layer 22 to remove contaminants, dehydrate the layer or modify the effective surface area and density of the treated surface (paragraph 73). Further, the plasma treatment provides an inert surface of the foundation barrier layer 22 for forming organic layers onto. An organic layer 24 over the foundational barrier layer 22 forms a foundation stack 20 (paragraph 78). A barrier stack 30 can then be applied over the foundation stack 20. The barrier stack 30 includes a barrier-stack barrier layer

32, which includes one or more sequentially deposited plies of inorganic material, such as three aluminum oxide plies (paragraph 79). A single layer of aluminum oxide can be about 300 angstroms thick. An organic layer 34 is over the barrier stack layer 32. The step of depositing the barrier stack 30 begins with deposition of the barrier-stack barrier layer 32 over the foundational organic layer 24 (paragraph 80). Following the optional plasma-treatment of the barrier-stack barrier layer 32, the barrier-stack organic layer 34 is deposited over the barrier-stack barrier layer 32 and polymerized. The layers 24 and 34 can be formed of an acrylate-based organic material (paragraph 46).

The rejection is based on using the plasma treatment step as taught by Huang to treat each of the plies of inorganic layers of a barrier-stack barrier layer "in order to remove impurities and to achieve a desired barrier layer film thickness" (office action page 4). This is an oversimplification of Huang's teachings. First, Huang uses the barrier layers in a contact and is concerned with the thickness of barrier layers because the dimension of the contact being fine. Huang wants to obtain barrier layer thickness of about 40-60 Angstroms. Graff '210, on the other hand, is forming multiple barrier layers on a substrate for an OLED device and very thin barrier layers are not critical. In fact, each barrier layer can have a thickness of about 300 Angstroms and person of skill in the art may find it disadvantageous to form thinner barrier layers, because water and gas may migrate through thinner layers faster than through thicker layers. Therefore, a person of skill in the art would not be motivated to reduce the thickness of Graff '210's inorganic barrier layers.

Huang also uses plasma treatment to remove carbon and oxide from a nitride barrier layer because during a thermal process, such impurities can create a film with a similar zeta potential as a further layer (the tungsten contact) causing repelling of the further layer (tungsten) upon deposition, which results in voids and poor adhesion. Thus, Huang removes the contaminants to prevent the poor adhesion problem that results when different materials with similar zeta potential are applied onto one another. Because Graff '210's multi-ply inorganic barrier stack is formed of multiple layers of the same material, adhesion is not a problem that Graff '210 is concerned with. Additionally, the adhesion problem in Huang is in part due to a high temperature process. Graff '210's device requires an organic layer that likely could not

withstand high temperatures of around 550-700° C and thus would not implement such a high temperature process that motivates the removal of impurities in Huang.

Graff '210 also uses plasma to remove contaminants, but does not indicate that contaminants, if any are formed, are problematic in the multiply barrier stack (barrier-stack barrier layer). Further, Graff '210 uses plasma treatment of the inorganic barrier layer to form an "inert" layer. As noted above, a person of skill in the art would not determine from Huang that the plasma treatment is used to form nucleation sites. Similarly, Graff '210 uses plasma to form an inert surface and does not form nucleation sites.

The Examiner notes under the rejection of claims 6, 7, 10 and 11 that "as multiple plies are deposited, the very first trace of the metal oxide or nitride hitting the surface of the ceramic barrier layer would inherently form a nucleation promoting material on at least a portion of the previously deposited ceramic layer." (office action pages 4, bottom through 5, top). As noted above, there is no reason that a person would plasma treat each of the three layers of Graff '210's barrier-stack barrier layer. Further, the claims require "forming a second ceramic barrier layer directly on the second surface of the first ceramic barrier layer *without continuing all defects of the first ceramic barrier layer*, wherein the second ceramic barrier layer is initiated at the first nucleation sites" (emphasis added). Assuming *arguendo* that the applying of a second ply onto a first ply "inherently form[s] nucleation promoting material", there is no indication that the second ply would not have all the defects of the first layer.

Applicant notes that a rejection under 35 U.S.C. §103 requires a conclusion that there is "subject matter as a whole [that] would have been obvious at the time the invention was made to a person having ordinary skill in the art." In *KSR Int'l Co. v. Teleflex Inc.*, 127 S.Ct. 1727 (2007), the Supreme Court of the United States demonstrated that an analysis under §103 involves: (1) determining what subject matter would have been obvious to one of ordinary skill in the art; and *then* (2) determining whether that subject matter is encompassed by a properly construed claim. Because a person of skill in the art reading Graff '210 and Huang together would not find it obvious to modify at least a portion of a second surface of a first ceramic barrier layer to introduce first nucleation sites on the second surface, applicant submits that there is no *prima facie* case of obviousness with respect to claims 1-3, 6, 7, 10-15 and 17-26 over Graff '210 in view of Huang.

Claim 27

Claim 27 is rejected under 35 U.S.C. § 103(a) as being unpatentable over Graff '210 in further view of U.S. Patent No. 6,522,067 ("Graff '067").

Claim 27 depends from claim 1. Graff '067 was not used to show any of the elements missing from Graff '210 that are required as limitations of claim 1. As no *prima facie* case of obviousness is pending with respect to claim 1, applicant notes that the same reasons apply to claim 27.

No fee is believed to be due. If, however, there are any charges or credits, please apply them to Deposit Account No. 06-1050.

Respectfully submitted,

Date: April 27, 2009

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